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EXAMINER SONG, MATTHEW J				
ART UNIT		PAPER NUMBER		
1765				

DATE MAILED: 10/27/2004

Please find below and/or attached an Office communication concerning this application or proceeding.

# Office Action Summary

Application No.

09/936,818

Applicant(s)

TAKAHASHI ET AL.

Examiner

Matthew J Song

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-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --  
Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

## Status

- 1) ☒ Responsive to communication(s) filed on 27 July 2004.
- 2a) ☒ This action is **FINAL**. 2b) ☐ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

## Disposition of Claims

- 4) ☒ Claim(s) 29-36,38-70,72-107 and 109-141 is/are pending in the application.
- 4a) Of the above claim(s) \_\_\_\_\_ is/are withdrawn from consideration.
- 5) ☐ Claim(s) \_\_\_\_\_ is/are allowed.
- 6) ☒ Claim(s) 29-36,38-70,72-107 and 109-141 is/are rejected.
- 7) ☐ Claim(s) \_\_\_\_\_ is/are objected to.
- 8) ☐ Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

## Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on \_\_\_\_\_ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.  
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).  
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

## Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some \* c) ☐ None of:
- ☐ Certified copies of the priority documents have been received.
  - ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.
  - ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

\* See the attached detailed Office action for a list of the certified copies not received.

## Attachment(s)

- ☐ Notice of References Cited (PTO-892)
- ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
- ☐ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)  
Paper No(s)/Mail Date \_\_\_\_\_
- ☐ Interview Summary (PTO-413)  
Paper No(s)/Mail Date. \_\_\_\_\_
- ☐ Notice of Informal Patent Application (PTO-152)
- ☐ Other: \_\_\_\_\_

## DETAILED ACTION

### *Claim Rejections - 35 USC § 103*

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

2. Claims 29-32, 34-36, 38-39, 42-50, 53-66, 68-70, 72-76, 79-87, 90, 92-103, 105-107, 109, 112-113, 116-126 and 132-141 are rejected under 35 U.S.C. 103(a) as being unpatentable over Adomi et al (US 5,442,201) in view of Tomomura (WO 98/44539), where US 6,358,822 is used as an accurate translation.

Adomi et al discloses growing an epitaxial layer of a compound semiconductor alloy doped with nitrogen and represented by the formula  $(Al_xGa_{1-x})_yIn_{1-y}P$  ( $0 < x \leq 1$ ,  $0 < y \leq 1$ ). Adomi et al also teaches using  $NH_3$  as a nitrogen doping source and the presence of organic aluminum is considered to contribute to efficient nitrogen doping, allowing a higher amount of nitrogen doped

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(col 2, ln 1-65). Adomi et al also teaches a light emitting device is fabricated by growing an n-type AlGaP layer 4, an N-doped AlGaP layer 3, an N-doped AlGaP layer 2 and a p-type AlGaP on a GaP substrate 5 (col 2, ln 66 to col 3, ln 5 and Fig 1). Adomi et al also discloses the n-type AlGaP layer 4 is formed by supplying a mixed source gases of TMAI, TMGa and PH<sub>3</sub> at a growth temperature of 850°C. Adomi et al also discloses the larger AlP molar ratio of an alloy AlGaP tends to have higher nitrogen concentration in the AlGaP when the NH<sub>3</sub> concentration is the same, resulting in more efficient nitrogen doping and it is extremely hard to dope nitrogen in GaP without the presence of TMAI (col 3, ln 6-67 and Fig 4). Adomi et al also discloses MOVPE is used as the epitaxial growth method and other methods such as CBE (chemical beam epitaxy) can be used (col 4, ln 1-67). Adomi et al also teaches nitrogen is doped to GaP layers near a p-n junction to substitute P sites in order to improve the light emitting efficiency (col 1, ln 20-35).

Adomi et al does not teach a substrate temperature of 450-640°C.

In a method of growing a Group III-V compound semiconductor, note entire reference, Tomomura teaches a Group III-V compound semiconductor layer including nitrogen and at least another Group V element grown by molecular beam epitaxy and is grown by irradiating a substrate with material molecular beams in crystal growth chamber so evacuated that the mean free path of material molecules is larger than the distance between the substrate and molecular beam sources, a nitrogen compound is used as a nitrogen source and molecules of the nitrogen compound decompose after they reach the substrate surface and only nitrogen atoms are incorporation into the growing semiconductor crystal (abstract). Tomomura also teaches a nitrogen hydride, NH<sub>3</sub>, is used as the nitrogen compound and the substrate temperature is

maintained at 500-750°C during crystal growth ('822 col 3, ln 1-50). Tomomura also teaches the substrate is a compound semiconductor which as a zinc blend structure and the substrate surface has an off-angle of 5-15° from {100} plane to a {111}A plane and decomposition is promoted and high incorporation efficiency of nitrogen is achieved on this substrate surface ('822 col 3, ln 50 to col 4, ln 5). Tomomura also teaches Al, Ga and In molecular beams were directed to a substrate by heating a solid metallic material using a Knudsen cell ('822 col 5, ln 10-55). Tomomura also teaches incorporation efficiency of nitrogen into the crystal can be improved ('822 col 4, ln 5-35). Tomomura also teaches GSMBE, CBE and MOMBE ('822 col 15, ln 1-30 and col 1, ln 5-55). Tomomura also teaches a timing chart for supplying reactant gases in sequence and one cycle of the source supply sequence is set in a range of 0.5 to 5 molecular layers to form a mixed crystal with uniform composition ('822 Fig 6 and col 10, ln 25-67).

It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Adomi et al with Tomomura method of forming Group III-V compound semiconductor at a temperature of 500-750°C using MBE to improve incorporation efficiency of nitrogen into a crystal and lower operating temperatures reduces operating costs.

Referring to claim 29, Adomi et al is silent to supplying aluminum and ammonium directly onto a surface of the crystal. Adomi et al teaches the chemical beam epitaxial method may be used (col 4, ln 40-46). Chemical beam epitaxy inherently supplies reactants directly to the substrate, as evidenced by Tomomura (WO 98/44539) below, which teaches irradiating a substrate with molecular beams of source material in a growth chamber, as in a chemical beam epitaxy (col 1, ln 10-25).

Referring to claim 29-30, Adomi et al discloses Al increases the efficiency of nitrogen doping and organic aluminum, i.e. vapor phase, is considered to contribute to efficient nitrogen doping (col 2, ln 25-35), this reads on applicant's decomposition of ammonium and adsorption of nitrogen is accelerated. Furthermore, Adomi et al discloses supplying ammonia and Aluminum directly onto a substrate surface as applicant, therefore the addition or crystallization of the nitrogen from the ammonia which is supplied directly onto the surface of the crystal into the surface of the crystal is accelerated by the aluminum supplied to the surface of the crystal is inherent because Adomi teaches a similar process of supplying aluminum and ammonia to form a nitrogen in a crystal.

Referring to claim 31, Adomi et al discloses an AlGaP layer doped with nitrogen, where the Al inherently exists throughout the layer, including the surface.

Referring to claim 32, Adomi et al discloses in Fig 4 that a larger molar ratio of AlP of an AlGaP alloy tends to have higher nitrogen concentration, this reads on applicant's an amount of nitrogen added to a crystal, a nitrogen composition, an amount of nitrogen adsorbed and amount of an element in the crystal surface is controlled by the Al. Also these would be inherent to Adomi et al.

Referring to claim 34, Adomi et al discloses CBE and MOVPE (col 4, ln 35-50). Adomi et al does not disclose MBE or GS-MBE. Chemical beam epitaxy (CBE) inherently is a form of MBE because CBE irradiates a substrate with molecular beams, as evidenced by Tomomura (WO 98/44539) below, which teaches GSMBE, CBE and MOMBE are generically referred to as MBE ('822 col 1, ln 10-50).

Referring to claim 35, Adomi et al discloses AlGaP:N (Fig 1) and P reads on applicant's Group V element other than nitrogen.

Referring to claim 36, Adomi et al discloses Phosphorous. Adomi et al does not disclose Arsenic or antimony. Arsenic, antimony and phosphorous are well-known Group V elements, used in the manufacture of Group III-V compound semiconductors. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Adomi et al by using Arsenic or antimony, which are well-known equivalents to phosphorous for the manufacturing of III-V compound semiconductors. Substitution of known equivalents for the same purpose is held to be obvious (MPEP 2144.06).

Referring to claim 37, Tomomura teaches a temperature of 500-750°C. Overlapping ranges are held to be obvious (MPEP 2144.05).

Referring to claim 38-39, 74-76, and 112-113, Tomomura teaches the substrate surface has an off-angle of 5-15° from {100} plane to a {111}A plane, this reads on applicant's surface slanted from a (100) surface in a [011] direction or a crystal face which is equivalent.

Referring to claim 42, Tomomura teaches an evacuated chamber and a mean free path of a molecule of each source material is longer than a distance between the substrate and a source material ('822 col 2, ln 50-67).

Referring to claim 43, Tomomura teaches solid sources in Knudsen cells.

Referring to claim 44, Tomomura teaches a nitrogen compound decomposed at the growth surface ('822 col 3, ln 1-10)

Referring to claims 45-46, Adomi et al discloses a GaP substrate (Fig1). Adomi et al does not disclose a substrate of GaAs, InP, GaSb or Si, which are well-known substrates used in the

formation of Group III-V compound semiconductors. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Adomi et al by using a GaAs, InP, GaSb or Si substrate because substitution of known equivalents for the same purpose is held to be obvious (MPEP 2144.06).

Referring to claim 47-48, Adomi et al teaches a nitrogen doped epitaxial layer is an active layer and a light emitting device (col 1, ln 50-68 and Fig 1).

Referring to claim 53-54, the combination of Adomi et al and Tomomura teach III-V compound semiconductor active layer used in a laser for optical fiber communication, this reads on a system ('822, col 1, 25-40).

Referring to claim 63 and 100, Adomi et al teaches growing an AlGaInPN crystal, supplying  $\text{NH}_3$  to a surface and the larger AlP molar ratio of an alloy of AlGaP tends to have a higher nitrogen concentration, this reads on applicant's adsorption of the nitrogen atom generated by decomposition of the ammonium supplied to the surface of the crystal is accelerated by the aluminum included in the surface of the crystal. Furthermore, Adomi et al discloses supplying ammonia to a substrate surface containing aluminum as applicant, therefore decomposition of the ammonium supplied to the surface of the crystal is accelerated by the aluminum included in the surface of the crystal is inherent because Adomi teaches a similar process of supplying ammonia to the surface of an aluminum containing crystal to form nitrogen in a crystal.

Referring to claim 73, Tomomura teaches the nitrogen material and the material of the group V elements are not supplied at the same time in Fig 6.



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3. Claims 40-41, 51-52, 77-78, 88-89, 91 and 114-115 are rejected under 35 U.S.C. 103(a) as being unpatentable over Adomi et al (US 5,442,201) in view of Tomomura (WO 98/44539), where US 6,358,822 is used as an accurate translation, as applied to claims 29-32, 34-36, 38-39, 42-50, 53-66, 68-70, 72-76, 79-87, 90, 92-103, 105-107, 109, 112-113, 116-126 and 132-141 above, and further in view of Ito (Empirical interatomic potentials for nitride compounds semiconductors).

The combination of Adomi et al and Tomomura teaches all of the limitations of claim 40, as discussed previously, the semiconductor layer A including at least aluminum and nitrogen in its composition but not including indium in its composition and the semiconductor layer B including at least indium in its composition but not including nitrogen in its composition.

Ito teaches versatility of empirical potentials with AlN for various monolayer superlattices with InP or InAs (Abstract). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Adomi et al and Tomomura with Ito superlattice of AlN and InP or InAs monolayers because superlattices reduce lattice mismatch strain between layers.

4. Claims 33, 67, 104, 110-111 and 127-131 are rejected under 35 U.S.C. 103(a) as being unpatentable over Adomi et al (US 5,442,201) in view of Tomomura (WO 98/44539), where US 6,358,822 is used as an accurate, as applied to claims 29-32, 34-36, 38-39, 42-50, 53-66, 68-70, 72-76, 79-87, 90, 92-103, 105-107, 109, 112-113, 116-126 and 132-141 above, and further in view of Motoda et al (US 5,872,022) and Ouchi (JP 10-152399), where US 6,046,096 is used as an accurate translation.

The combination of Adomi et al and Tomomura teaches all of the limitations of claim 110, as discussed previously, except etching the layered structure while masking a portion of the layered structure such that the first semiconductor layer is exposed in a portion of an etch surface and supplying ammonium to the etched surface.

In a method of forming a compound semiconductor structure, note entire reference, Ouchi teaches a portion of a compound semiconductor is irradiated with material including at least nitrogen and a group V element of the irradiated portion is substituted with nitrogen (abstract). Ouchi also teaches a GaAs substrate **501**, a grating **502** formed on the substrate and performing a nitrification process around a recess portion to form a large number of InGaAsN quantum wires **505** along the recess portion at a substrate temperature of 800°C ('096 col 10, ln 35 to col 11, ln 5 and col 7, ln 20-35 and Fig 5). Ouchi also teaches when substitution by nitrogen is selectively conducted and a semiconductor layer containing nitrogen and layer without nitrogen are formed in a distributed pattern, a fine structure, such as a quantum wire can be readily fabricated ('096 col 11, ln 10 to col 12, ln 25). Ouchi also teaches improved characteristics, such as low threshold, is achieved by a device with a quantum wire structure ('096 col 6, ln 1-50). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Adomi et al and Tomomura with Ouchi's selective nitrification to form a quantum wire structure to improve the characteristics of the device.

In a method of forming a semiconductor device, note entire reference, Motoda et al teaches a diffraction grating process, where an insulating film is formed on a diffraction grating layer **25**, a stripe-shaped diffraction grating pattern **32** is formed and used as a mask. Motoda et

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al also teaches the diffraction grating layer is etched, thereby forming a groove having a (111) facet surface and producing a diffraction grating (col 16, ln 30 to col 17, ln 45 and Figs 14(a)-14(f)). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Adomi et al, Tomomura and Ouchi with Motoda et al's method of forming a grating by etching because deposition and etching to form the grating can be performed in the same apparatus to avoid oxidation of the oxidation and contamination, which is detrimental to the device (col 2, ln 1-35).

Referring to claim 33, the combination of Adomi et al, Tomomura, Ouchi and Motoda et al teach forming a diffraction grating pattern, where nitrification occurs in a recessed portion, this reads on applicant's restricted region.

Referring to claim 110, the combination of Adomi et al, Tomomura, Ouchi and Motoda et al teach forming a grating pattern by etching and supplying ammonium to a substrate to substitute a constituent element in the first semiconductor layer in a layered structure.

Referring to claim 111, Motoda et al teaches a (111) surface.

Referring to claim 127, the combination of Adomi et al, Tomomura, Ouchi and Motoda et al teach a diffraction grating and a periodic wire structure at a  $\frac{1}{2}$  of the pitch of the grating ('96 Fig 5) and substitution of nitrogen.

Referring to claim 128, the combination of Adomi et al, Tomomura, Ouchi and Motoda et al teaches a quantum wire.

Referring to claim 129, the combination of Adomi et al, Tomomura, Ouchi and Motoda et al teaches ammonium.

***Response to Arguments***

5. Applicant's arguments filed 7/27/2004 have been fully considered but they are not persuasive.

Applicants' argument that Adomi disclose using MOVPE, therefore a person of ordinary skill in the art would not have used the MBE process taught by Tomomura because the deposition processes are entirely unrelated is noted but is not found persuasive. The Examiner admitted that Adomi's invention is directed to MOVPE process for deposition, which uses deposition temperatures greater than the claimed temperature range of 450-640°C. However, the Examiner maintains that Adomi teaches other methods such as the chemical beam epitaxy method can also be used. Tomomura teaches a Molecular beam epitaxy (MBE) process, which covers chemical beam epitaxy (col 15, ln 1-15). Tomomura also teaches a substrate temperature of 580°C to grow a GaInNAs mixed crystal layer and a mixed crystal layer of AlGaAs (col 5, ln 45-55). Therefore, it would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Adomi with the process taught by Tomomura because Adomi specifically teaches other process, such as the process taught by Tomomura, may be used instead of MOVPE and the process taught by Tomomura uses lower substrate temperatures within the claimed temperature range.

Applicants' argument that there is no suggestion in the art for using a temperature of 450-680°C when forming a crystal layer using a combination of nitrogen and aluminum is noted but is not found persuasive. Tomomura teaches growing a mixed crystal comprising at least Al or Ga and Nitrogen and a substrate temperature of 400-750°C (col 15, ln 15-30 and claim 13), specifically 580°C (col 5, ln 45-60). Tomomura specifically teaches using 580°C to grow

AlGaAs layers and GaInNAs layers (col 5, ln 45-60), which reads on applicants' claimed range, and the present invention can be used to grow other mixed crystals of III-V compound semiconductors which include nitrogen and at least Al (col 15, ln 15-31). Furthermore, Tomomura et al also teaches a range of substrate temperatures of 400-750°C, which overlaps the claimed temperature range and overlapping ranges are held to be obvious (MPEP 2144.05).

Applicants' argument of unexpected results is noted but is not found persuasive. Tomomura specifically teaches a substrate temperature of 580°C, which is within the claimed range.

Applicants' argument that the prior does not teach using a combination of nitrogen and aluminum is noted but is not found persuasive. Adomi teaches doping a AlGaP layer with nitrogen by supplying NH<sub>3</sub> and TMAI (col 2, ln 45 to col 3, ln 67), this reads on applicants forming a crystal layer using a combination of nitrogen and aluminum.

In response to applicant's argument that there is no suggestion to combine the references, the examiner recognizes that obviousness can only be established by combining or modifying the teachings of the prior art to produce the claimed invention where there is some teaching, suggestion, or motivation to do so found either in the references themselves or in the knowledge generally available to one of ordinary skill in the art. See *In re Fine*, 837 F.2d 1071, 5 USPQ2d 1596 (Fed. Cir. 1988) and *In re Jones*, 958 F.2d 347, 21 USPQ2d 1941 (Fed. Cir. 1992). In this case, Adomi teaches other methods of crystal growth may be used, such as chemical beam epitaxy (col 4, ln 35-50). Tomomura teaches a Chemical beam epitaxial method (CBE); therefore a person of ordinary skill would have been motivated to use the method of crystal growth taught by Tomomura because Adomi suggests using CBE. MOVPE and MBE are different methods of

deposition using different substrate temperature, but Adomi specifically teaches other methods of crystal growth can be used.

### ***Conclusion***

6. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire **THREE MONTHS** from the mailing date of this action. In the event a first reply is filed within **TWO MONTHS** of the mailing date of this final action and the advisory action is not mailed until after the end of the **THREE-MONTH** shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than **SIX MONTHS** from the date of this final action.

7. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Matthew J Song whose telephone number is 571-272-1468. The examiner can normally be reached on M-F 9:00-5:00.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nadine Norton can be reached on 571-272-1465. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

Matthew J Song  
Examiner  
Art Unit 1765

MJS

NADINE G. NORTON  
SUPERVISORY PATENT EXAMINER  
